Text Comprehension Web-based Adaptive Environment for Distance Learning – Exploitation in Computer Science Education

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Abstract. This dissertation contributes to the field of learning in the domain of Computer Science. We investigated the effects of background-knowledge and text-cohesion on learning from texts in Computer Science. Our results showed that students with low background knowledge appeared to benefit from a high-cohesion text, whereas students with high background knowledge from a low-cohesion text. Based on our results, we designed and developed the Adaptive Learning Models from texts and Activities (ALMA) environment which supports the processes of learning and assessment via: 1) texts differing in local and global cohesion for students with low, medium and high background knowledge, 2) activities corresponding to different levels of comprehension which prompt the student to practically implement different text-reading strategies, with the recommended activity sequence adapted to the student's learning style, 3) an overall framework for informing, guiding and supporting students in performing the activities, 4) individualized support and guidance according to student-specific characteristics. ALMA also, supports students in distance learning or in blended learning in which students are submitted to face-to-face learning supported by computer technology. The adaptive techniques provided via ALMA are: a) adaptive presentation and b) adaptive navigation. Digital learning material, in accordance to the text comprehension model described by Kintsch (1998), was introduced into the ALMA environment. The material includes texts of varying local and global cohesion and activities corresponding to different comprehension levels and appropriate for all learning styles. This material can be exploited in either distance or blended learning.

1 Introduction

Learning from texts is a complex process and till now, not completely understood [1,2]. In order to optimize learning, should one make the comprehension process as easy as possible, or should one, as many educators insist, ensure that the learner participates actively and intentionally in the process of constructing the meaning of a text [3]? Specifically, should the readers' task be facilitated by improving the comprehensibility of a text or should the readers' active involvement be increased by placing obstacles in their way? In the second case, what sort of obstacles will have beneficial effects on learning and under what conditions? The approach to this question has been the study of characteristics of the text, the characteristics of the individual reader and how these factors affect text comprehension.

A considerable number of empirical studies have been conducted in order to answer this question. Many of them have demonstrated that readers' background knowledge facilitates and enhances comprehension and learning [4]. These studies have also shown that readers with greater background knowledge express more interest in the reading material and employ more effective reading strategies. Additionally, experts tend to put more effort into learning than do novices [5]. Text comprehension can also be facilitated and enhanced by rewriting poorly written texts in order to be more

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cohesive and to provide the reader with all the information needed for a good comprehension [6,7, 8]. Text coherence refers to the extent to which a reader is able to understand the relations between ideas in a text. This is generally dependent on whether these relations are explicit in the text.

Nevertheless, a cohesive text representation does not always result in better learning. Readers with appropriate knowledge do not always employ that knowledge for learning. They also tend to take the path of least resistance and if they have the feeling that they are easily understanding the text they read, they may not bother to activate their knowledge and form the links between it and the text that guarantee learning. Thus, there exists an instructional need to stimulate reader activity [3]. Consequently, the advantages found for facilitating the reading process by making text more cohesive and the disadvantages demonstrated for facilitating the learning process present contradictory findings.

According to Kintsch, there is no text comprehension that does not require the reader to apply knowledge: lexical, syntactic and semantic knowledge, domain knowledge, personal experience and so on. Ideally a text should contain the new information a reader needs to know plus just enough old information to allow the reader to link the new information with what is already known. Texts that contain too much that the reader already knows are boring to read and, indeed, confusing (e.g., legal and insurance documents that leave nothing to be taken for granted). Consequently, too much coherence and explication may not necessarily be a good thing.

The way in which cohesion manipulations influence the comprehension and consequently the learning from computer science texts (e.g. Computer Networks texts) may differ from that of social and natural sciences texts. Thus, it is of great importance to investigate learning from texts in Computer Science. Our study contributes to the field of learning from texts in the domain of Computer Science. Based on previous research in various other domains, we further examined the effects of background knowledge on learning from high- and low-cohesion texts in Computer Science. Specifically, we investigated the learning from texts in "Local Networks Topologies" by undergraduate low- and high-knowledge students.

For this purpose, we conducted three empirical studies [9,10]: (1) The main purpose of the 1st study was to investigate the effects of text-cohesion on low and high-background knowledge students learning in Computer Science. We used texts concerning the domain of "Local Networks Topologies". Participants with low- and high-background knowledge about the domain of the text were included. They were separated randomly in four groups (A, B, C, and D). Each group was given one from four text versions of different cohesion. Tasks differentially sensitive to textbase and situation model constructions were used. The participants were tested on memory recall and deep comprehension, (2)The main purpose of the present study was to investigate the effects of text-cohesion on high-knowledge students learning in computer science. We used texts concerning the domain of "Local Networks Topologies", (3)The purpose of the 3rd study was twofold. Firstly, to assess reading comprehension of students with high-and low background knowledge using texts in Computer Science with low- and high local cohesion. Next, to examine how question format (multiple-choice vs. open-ended) influence the assessment of science text comprehension among undergraduate students. We attempted to compare multiple-choice and open-ended question by directly transforming comprehension questions from one format to the other.

According to (ACM and IEEE) [11]:

- Computer science texts are complex depending on factors mainly inherent in the texts. Much of their content is abstract and technical, far removed from everyday experience.
- Computer science texts support students to utilize concepts from many different fields. All computer science students must learn to integrate theory and practice, to recognize the importance of abstraction, and to appreciate the value of good engineering design.
- Computer science texts support students to understand the theoretical underpinnings of the discipline and also how that theory influences practice.
- Computer science texts support students to develop a high-level understanding of systems as a whole. This understanding must transcend the implementation details

of the various components to encompass an appreciation for the structure of computer systems and the processes involved in their construction and analysis.

- Computer science texts must help students to encounter many recurring themes such as abstraction, complexity, and evolutionary change. They will also encounter principles, e.g. those associated with caching, (e.g. the principle of locality), with sharing a common resource, with security, with concurrency, and so on.

2 The Construction-Integration Model

The construction-integration model is an extension of earlier comprehension models [12, 13], primarily specifying computationally the role of prior knowledge during the comprehension process. It distinguishes several different levels that readers construct during the mental representation of a text. *Text base* and *situation model* understanding are most relevant for the objectives of this study. The text base contains the information that is directly expressed in the text, organized and structured in the same way as by the author. It has a local and global structure (micro- and macro-structure respectively). Micro-structure refers to local text properties, macro-structure to the global organization of text. The situation description constructed by the learner on the basis of a text, as well as prior knowledge and experience, is called the *situation model*.

Text Cohesion

The degree to which the concepts, ideas and relations with a text are explicit has been referred to as *text cohesion,* whereas the effect of text cohesion on readers' comprehension has been referred to as *text coherence* [14]. Text coherence refers to the extent to which a reader is able to understand the relations between ideas in a text and this is generally dependent on whether these relations are explicit in the text.

The Measurement of Learning

Some measures are more indicative of text memory (e.g. recognition, text-based questions, and text-recall) whereas other measures are more sensitive to learning (e.g., bridging- inference questions, recall elaborations, problem-solving tasks, keyword sorting tasks). The former are referred to as text base measures because a cohesive text base understanding is all that is required for a high performance. The latter are referred to as situation model measures because, in order to perform well, the reader must have formed a well-integrated situation model of the text during the comprehension process [3].

3 The 2nd Empirical Study-Results

3.1 Reading Rates

The time required for each participant to read the text, was recorded. The number of words in each text was divided by the reading time yielding the average number of words per minute. Participants read the text twice, yielding two reading rate scores. The results are presented in Tables 1a and 1b.

Readers read the text much more slowly the first time (*M*=108 words/minute) in relation with the second (*M*=159 words/min). A significant main effect was obtained for local cohesion, ($F(1,61) = 16.608$, $p<0.001$, for the 1st reading and $F(1,61)= 14.259$, $p<0.001$, for the 2nd reading). Students who read the texts with the maximum local cohesion (L) had higher reading rates scores (*M* =132 words/min for the 1st reading and *M*=196 words/min for the 2nd reading) than students who read the texts with the minimum local cohesion (l) (*M*=85 for the 1st reading and *M*=123 for the 2nd reading). This was a low difference (Partial Eta Squared=0.214 for the 1st reading and Partial Eta Squared=0.189 for the 2nd reading). This result indicates that the minimally cohesive text at the local level requires more inferences than does the high cohesion text.

Table 1a: The mean (standard deviation) of reading rates in words per minute

Local cohesion	Global cohesion	N	1st reading		2nd reading	
			Mean	SD	Mean	SD
Low	low	16	87	42	141	61
	high	16	84	41	104	55
	Total	*32*	*85*	*41*	*123*	*58*
High	low	16	131	39	201	97
	high	17	132	58	191	92
	Total	*33*	*132*	*49*	*196*	*94*
Total	low	32	107	46	168	83
	high	33	110	56	150	87
	Total	*65*	*108*	*51*	*159*	*85*

Table 1b: Reading rates: Tests of Between-Subjects Effects

Source	1st reading			2nd reading		
	F	Sig.	Partial Eta Squared	F	Sig	Partial Eta Squared
Local cohesion	16.608	0.000	0.214	14.259	0.000	0.189
Global cohesion	0.005	0.943	0.000	1.474	0.229	0.024
Local cohesion* global cohesion	0.036	0.851	0.001	0.491	0.486	0.008

Participants also read more quickly texts with the minimum global cohesion but there was not obtained a significant main effect $F(1,61)=0.005$, $p=0.943$, for the 1st reading and $F(1,61)= 1.474$, $p=0.229$ for the 2nd reading) indicating that students who read the texts with the high global cohesion had about the same reading rates scores ($M=107$ words/min for the 1st reading and $M=168$ words/min for the 2nd reading) with the students who read the texts with the low global cohesion ($M=110$ words/min, for the 1st reading and $M=150$ words/min for the 2nd reading) (Partial Eta Squared=.000, for the 1st reading and Partial Eta Squared=0.024 for the 2nd reading). Thus, the absence of an explicit macrostructure in the text did not slow high-knowledge participants down.The interaction effect between local and global cohesion was not statistically significant ($F(1,61)=0.036$, $p=0.851$, Partial Eta Squared=0.001, for the 1st reading and $F(1,61)=0.491$, $p=0.486$, Partial Eta Squared=0.008, for the 2nd reading) indicating that the local cohesion difference scores do not depend on the particular global cohesion (low or high). These results are consistent with McNamara et al., (1996).

3.2 Text Recall

The text paragraph concerning “Tree Topology” was propositionalized in the four text versions. In order to compare recall for the different text versions, the analysis included only those propositions containing information common to all four texts (i.e., those comprising the lg text). This scoring method allows by-item analyses to be performed because the propositions that are scored remain the same for all participants regardless of text. There were 20 micro propositions and 3 macro propositions common to all texts.

Participants recalled the text twice, once after the first and again after the second reading of the text. The two results for each participant were pooled and scored collectively. Thus, a composite recall was formed of the propositions provided in the first recall together with any additional (non repeated) propositions that occurred in the second recall. Two-way ANOVA by participants and by items was performed on proportional recall including the factors local cohesion, global cohesion and proposition type. Text recall-scores are presented in Tables 2a and 2b.

Participants reproduced texts well enough. In the recall of *micro-propositions* there was a significant main effect for local cohesion $F(1,61)=6.438$, $p=0.014$. Students who read the text with the low local cohesion had higher scores ($M=0.54$) than those who read the text with the high local cohesion ($M=0.44$). The effect size was (Partial Eta Square=.095). This result indicates that students constructed a better text base with the text of low local cohesion. In the recall of *micro-propositions*, there was not a significant main effect for global cohesion $F(1,61)=0.021$, $p=0.886$. Students who read the text with the low global cohesion had the same scores ($M=0.49$) with those who read the text with the high global cohesion ($M=0.49$). The effect size was (Partial Eta Square=.00). This result indicates that students were able to construct a good text base both with low and high global text cohesion. This result is consistent with McNamara et al., (1996). The interaction effect was not significant in the recall of micro propositions ($F(1, 61) = 0.209$, $p=0.649$). The effect size was (Partial Eta Square = 0.003) indicating that the local cohesion difference do not depend on the particular global cohesion (low or high).

Table 2a: Text-Recall scores

Local cohesion	Global cohesion	N	Proportion of Micro-propositions recalled		Proportion of Macro-propositions recalled	
			Mean	SD	Mean	SD
Low	low	16	0.53	0.14	0.67	0.44
	high	16	0.56	0.17	0.59	0.43
	Total	*32*	*0.54*	*0.15*	*0.63*	*0.43*
High	low	16	0.45	0.17	0.53	0.32
	high	17	0.44	0.16	0.62	0.45
	Total	*33*	*0.44*	*0.16*	*0.57*	*0.39*
Total	low	32	0.49	0.16	0.61	0.39
	high	33	0.49	0.17	0.60	0.43
	Total	*65*	*0.49*	*0.16*	*0.60*	*0.41*

Table 2b: Text-Recall scores: Tests of Between-Subjects Effects

Source	Recall of micro propositions			Recall of macro propositions		
	F	Sig.	Partial Eta Squared	F	Sig	Partial Eta Squared
Local cohesion	6.438	0.014	0.095	0.317	0.575	0.005
Global cohesion	0.021	0.886	0.000	0.000	0.985	0.000
Local cohesion* global cohesion	0.209	0.649	0.003	0.675	0.414	0.011

In the recall of *macro-propositions* there was not a significant main effect for local cohesion, ($F(1,61)=0.317$, p=0.575). Students who read the text with the low local cohesion had the same scores ($M=0.63$) with those who read the text with the high local cohesion ($M=0.57$). The effect size was weak (Partial Eta Square=0.005). There was not a significant main effect for global cohesion, in the recall of *macro-propositions* ($F(1,61)=0.000$, $p=0.985$). Students who read the text with the low global cohesion had about the same scores ($M=0.61$) with those who read the text with the high global cohesion ($M=0.60$). The effect size was (Partial Eta Square=0.000). The interaction effect was not significant, $F(1,61)=0.675$, $p=0.414$. The effect size was (Partial Eta Squared=0.011). These results indicate that students were able to construct a good text base both with low and high global text cohesion and are consistent with McNamara et al., (1996).

3.3 Assessment Reading Questions

Participants answered 8 open-ended questions after each of the two readings of the text. First or second assessment questionnaire completion times were combined because they were similar. There were no significant differences between the four text conditions in terms of the total amount of time spent answering questions (M=12 min, $F(3,61)=0.476$, $MSE=0.47$, $p=0.7$). The evaluation of this task was performed by the two course teachers and was expressed as percentage correct. The marking of the performance measure was indeed blinded, i.e. the markers did not know which group each student was in. Participants answered 8 open-ended questions after each of the two readings of the text. First or second assessment questionnaire completion times were combined because they were similar. There were no significant differences between the four text conditions in terms of the total amount of time spent answering questions (*M*=12 min, *F*(3,61)=0.476, *MSE*=0.47, *p*=0.7). The evaluation of this task was performed by the two course teachers and was expressed as percentage correct. The marking of the performance measure was indeed blinded, i.e. the markers did not know which group each student was in. The results are shown in Tables 3a and 3b.

Table 3a: Proportion of correct responses to the assessment reading questions

Local cohesion	Global cohesion	N	Text-based questions		Bridging – Inference questions		Elaborative-inference questions		Problem-solving questions	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
Low	Low	16	0.72	0.14	0.93	0.12	0.76	0.10	0.92	0.05
	High	16	0.65	0.16	0.78	0.21	0.66	0.19	0.75	0.17
	Total	*32*	*0.68*	*0.15*	*0.85*	*0.16*	*0.71*	*0.14*	*0.83*	*0.11*
High	Low	16	0.61	0.17	0.76	0.15	0.52	0.21	0.80	0.14
	High	17	0.70	0.17	0.88	0.15	0.68	0.18	0.74	0.13
	Total	*33*	*0.65*	*0.17*	*0.82*	*0.15*	*0.60*	*0.19*	*0.77*	*0.13*
Total	Low	33	0.67	0.16	0.85	0.16	0.65	0.20	0.87	0.12
	High	32	0.67	0.16	0.83	0.19	0.67	0.18	0.74	0.15
	Total	*65*	*0.67*	*0.16*	*0.84*	*0.17*	*0.66*	*0.19*	*0.81*	*0.13*

Table 3b: Assessment reading questions: Tests of Between-Subjects Effects

Cohesion	**Text-based questions**			**Bridging-inference questions**			**Elaborative-inference questions**			**Problem-solving questions**		
	F	Sig.	Partial Eta Squared	F	Sig.	Partial Eta Squared	F	Sig.	Partial Eta Squared	F	Sig.	Partial Eta Squared
local	0.524	0.472	0.009	0.681	0.412	0.011	6.819	0.011	0.101	4.108	0.047	0.063
global	0.049	0.826	0.001	0.114	0.737	0.002	0.424	0.518	0.007	13.583	0.000	0.182
local * global	3.300	0.074	0.051	11.646	0.001	0.160	8.653	0.005	0.124	2.252	0.139	0.036

For *text-based* question scores, there was not a significant main effect neither for local cohesion (*F*(1,61)=0.524, *p*=0.472) nor for global cohesion (*F*(1,61)=0.049, *p*=0.826). Students who read the texts with the low local cohesion had about the same scores (*M*=0.68) with those reading the texts with the high local cohesion (*M*=0.65). In addition, students who read the texts with low global cohesion had the same scores (*M*=0.67) with those reading the high global cohesion texts (*M*=0.67). The effect size for local cohesion was (Partial Eta Square=0.009) and for global cohesion was (Partial Eta Square=0.001). The interaction effect was not significant, (*F*(1,61)=3.300, *p*=0.074) indicating that the local cohesion difference scores do not depend on the particular global cohesion (low or high). The effect size was (Partial Eta Square=0.051).These results indicate that students were able to construct a good text base both with low and high local and global text cohesion and they are consistent with McNamara et al., (1996).

For *bridging-inference* question scores, there was not a significant main effect neither for local cohesion (*F*(1,61)=0.681, *p*=0.412) nor for global cohesion (*F*(1,61)=0.114, *p*=0.737). Students who read the texts with the low local cohesion had better scores (*M*=0.85) than those who read the texts with the high local cohesion (*M*=0.82) but the difference was not statistically significant. In addition, students who read the texts with low global cohesion had about the same scores (*M*=0.85) with those reading the high global cohesion texts (*M*=0.83). The effect size for local cohesion was (Partial Eta Square=0.011) and for global cohesion was (Partial Eta Square=0.002). The interaction effect was significant, (*F* (1, 61) = 11.646, *p*=0.001) indicating, although the effect size was relatively weak (Partial Eta Square = 0.160), that the local cohesion difference scores depend on the particular global cohesion (low or high).

For *elaborative-inference question* scores, a significant main effect was obtained for local cohesion, ($F(1,61)=6.819$, $p=0.011$). Students reading texts with low local cohesion had significantly higher scores ($M=0.71$) than students with high local cohesion texts ($M=0.60$). The effect size was (Partial Eta Squared = 0.101). However, there was not obtained a significant effect for global cohesion, ($F(1,61)= 0.424$, $p=0.518$). Students reading texts with low global cohesion had about the same scores ($M=0.65$) with the students reading high global cohesion texts ($M=0.67$). The effect size was (Partial Eta Squared=0.007). The interaction effect between local and global text cohesion was significant, ($F(1,61)=8.653$, p=0.005), meaning that the local cohesion difference scores, depend on the particular global cohesion (low or high). The effect size was (Partial Eta Squared = 0.124).

For *problem solving* question scores, a significant main effect was obtained for local cohesion, ($F(1,61)=4.108$, $p=0.047$). Students reading texts with low local cohesion had significantly higher scores ($M=0.83$) than students with high local cohesion texts ($M=0.77$). The effect size was (Partial Eta Squared = 0.063). Additionally, a significant main effect was obtained for global cohesion, ($F(1,61)= 13.583$, $p=0.000$). Students reading texts with low global cohesion had significantly higher scores ($M=$ 0.87) than students with high global cohesion texts ($M=0.74$). The effect size was (Partial Eta Squared=0 .182). The interaction effect between local and global text cohesion was not significant, ($F(1,61)=2.252$, $p=0.139$), meaning that the local cohesion difference scores do not depend on the particular global cohesion (low or high). The effect size was (Partial Eta Squared = 0.036).

3.4 Sorting Activity

Participants were randomly assigned in the four text versions. The sorting data were used to determine how strongly reading the text affected the reader's conceptual structure concerning the information in the text. We were not interested in how well or reasonably participants sort the items, but in the degree to which the information presented in the text, influences their sorting. The results of this analysis are shown in Tables 4a and 4b. The evaluation of this task was performed by the two course teachers and was expressed as percentage correct. The marking of the performance measure was indeed blinded, i.e. the markers did not know which group each student was in.

Table 4a: Proportion of correct sorted data

Local cohesion	Global cohesion	N	Pre-reading sorting activity		Post-reading sorting activity		Improvement in sorting activity scores	
			Mean	SD	Mean	SD	Mean	SD
Low	Low	16	0.78	0.15	0.94	0.11	0.16	0.11
	High	16	0.71	0.21	0.89	0.11	0.18	0.17
	Total	*32*	*0.74*	*0.18*	*0.91*	*0.11*	*0.17*	*0.14*
High	Low	16	0.69	0.21	0.75	0.22	0.06	0.02
	High	17	0.88	0.12	0.91	0.13	0.03	0.03
	Total	*33*	*0.78*	*0.16*	*0.83*	*0.18*	*0.04*	*0.02*
Total	Low	33	0.74	0.18	0.86	0.19	0.11	0.09
	High	32	0.80	0.19	0.90	0.12	0.10	0.14
	Total	*65*	*0.77*	*0.18*	*0.88*	*0.15*	*0.11*	*0.11*

Table 4b: Sorting activity: Tests of Between-Subjects Effects

Cohesion	Pre-reading sorting activity			Post-reading sorting activity			Improvement in sorting activity		
	F	Sig.	Partial Eta Squared	F	Sig.	Partial Eta Squared	F	Sig.	Partial Eta Squared
local	0.963	0.330	0.016	4.876	0.031	0.074	22.755	0.000	0.272
global	1.869	0.177	0.030	1.866	0.177	0.030	0.033	0.857	0.001
local * global	8.405	0.005	0.121	8.652	0.005	0.124	1.057	0.308	0.017

According to Tables 4a and 4b, in *pre-reading sorting activity*, a significant main effect was obtained for local cohesion, $F(1,61)=0.963$, $p=0.330$. In *post-reading sorting activity* a significant main effect was obtained for local cohesion, $F(1,61)=4.876$, $p=0.031$. Students reading the texts with low local text cohesion, had significantly higher scores ($M=0.91$) than students who read the texts of high local text cohesion ($M=0.83$). The effect size was (Partial Eta Squared = 0.074). There was not obtained a significant main effect for global cohesion, $F(1,61)=1.866$, $p=0.177$. Students reading the texts with low global text cohesion, had about the same scores ($M=0.86$) with those reading high global text cohesion ($M=0.90$). The effect size was (Partial Eta Squared=0.030). The interaction effect was also significant, ($F(1,61)=8.652$, $p=0.005$, Partial Eta Squared=0.124) indicating that the local cohesion difference scores depends on the particular global cohesion (low or high).

As we are interested in the degree to which the information presented in the text, influences students' sorting, the most important is the *improvement in sorting activity*. A significant main effect was obtained for local cohesion, $F(1,61)=22.755$, $p=0.000$. Students reading the texts with low local text cohesion, had significantly higher improvement ($M=0.17$) than students reading the texts of high text cohesion ($M=0.04$). The effect size was (Partial Eta Squared=0.272). There was not obtained a significant main effect for global cohesion ($F(1,61)=0.033$, $p=0.857$, Partial Eta Squared=0.001). The interaction effect was not significant, ($F(1,61)=1.057$, $p=0.308$, Partial Eta Squared=0.017) indicating that the local cohesion difference scores, do not depend on the particular global cohesion category (low or high). Consequently, high-knowledge readers developed a better situation model with the texts of minimum local cohesion (lg, lG). This result is consistent with McNamara et al., (1996) for high-knowledge readers and Kintsch & McNamara, (1996, 1st experiment).

3.5 Conclusions

Our study demonstrated that learners with adequate background knowledge, reading a text with minimum cohesion were forced to infer unstated relations in the text and were engaged in compensatory processing at the level of the situation model. This enabled them to understand the text more deeply than if they were given a more cohesive text. These results confirm the findings of previous studies, such as in the domain of heart disease [4]. Understanding the ways and directions in which text structure, individual differences and comprehension measures interact, is vital for a complete theoretical account of text comprehension, as well as an educational approach to using texts in a classroom. W. Kintsch's model of text comprehension has provided us with a framework to approach these issues.

This research suggests an approach in which the cohesion level of the text is adjusted to the student's level of knowledge, so that reading becomes challenging enough to stimulate active processing but not so difficult as to break down comprehension. This would mean constructing several versions of a text in order to accommodate varying levels of knowledge among readers. According to McNamara et al. [4], the idea of "customizing" a textbook is not as impractical as it may seem. For example, textbook publishers provide instructional texts that are a composite of particular subject areas requested by individual teachers. Moreover, the kind of educational application of customized text is easily within the capability of present day hypertext computer systems. Text could be presented on a computer screen with interspersed questions or tasks designed to assess a student's comprehension online. Instructional text could then be presented at the level of cohesion that is appropriate to the student's current level of understanding so that it encourages inferencing but also ensures that the reader is able to do so. In this way, students are forced to use their knowledge as they read, allowing effective learning from a textbook to be achieved by a much wider range of students than is possible with a single text targeted at a supposed average reader.

Moreover, as it concerns the assessment using open-ended questions versus the assessment using multiple choice questions, our 3rd study confirmed that comprehension assessments using open-ended questions are comparable to those using multiple-choice questions only in the case of elaborative-inference questions for both students with high- and low background knowledge. The results show that elaborative-inference questions were more difficult than text-based and bridging-

inference questions regardless of the question format. This occurs because in text-based and bridging-inference multiple choice questions with very selective and controlled distracter options might never be exactly the same as open-ended questions because multiple–choice questions provide richer retrieval cues than corresponding open-ended questions [16]. On the other hand, in order an elaborative-inference question to be answered, linking text information and information from outside knowledge is required. Thus, answering this type of question requires the integration of text information with background knowledge. In this case the distracter options do not include information which is contained entirely in the text.
Consequently elaborative-inference questions assess the situation model a student constructs during reading both in open-ended and in multiple choice format. On the other hand bridging-inference questions assess the situation model a student construct during reading only in open-ended format whereas bridging-inference questions in multiple choice format assess the text-base model as do text-based questions in both formats.

4. Text Comprehension Web-based Learning Environments

In the field of text comprehension, many researchers have been examining issues focusing on assisting comprehension through personalized learning environments. Point & Query (P&Q) is an environment where students learned entirely by asking questions and interpreting answers to questions [17]. AutoTutor, holds a conversation in natural language that coaches the student in constructing a good explanation in an answer, that corrects misconceptions, and that answers student questions [17]. MetaTutor, a hypermedia environment, designed to train and foster students' self-regulated learning (SRL) [18, 19]. ReTuDiS is a tutorial dialogue system for learner modeling text comprehension through personalized reflective dialogue [20]. Interactive Strategy Training for Active Reading and Thinking (i-START) is a web-based application that provides young adolescent to college students with high-level reading training to improve comprehension of science texts. i-START is modeled after an effective, human-delivered intervention called self-explanation reading training (SERT), which trains readers to use active reading strategies to self-explain difficult texts more effectively [21, 22].

5. An Outline of the ALMA Environment (Adaptive Learning Models from Texts and Activities)

Fig. 1: An Outline of the ALMA Environment

ALMA [23] actively engages students in the learning process. It takes into account readers' background knowledge in order to propose the appropriate text version from four versions of a text with the same content but different cohesion at the local and global level. To achieve this goal, it suggests that the student performs a background knowledge assessment test, with scores characterized as "high", "median" and "low". ALMA motivates high knowledge students to read the minimally cohesive text at both local and global levels (lg), median knowledge students to read the text with maximum local and minimum global cohesion (Lg) or with minimum local and maximum global cohesion (lG) and low knowledge students to read the maximally cohesive text (LG). ALMA also allows the student to choose the preferred version of text and records the time spent reading it. The following three types of rules were used to maximize local cohesion: (1) replacing pronouns with noun phrases when the referent was potentially ambiguous (e.g. In the phrase: *"This has been very popular for exchanging music files via the internet"*, we replace *"This"* by *"The peer-to-peer model"*. (2) Adding descriptive elaborations linking unfamiliar and familiar concepts (e.g., *"In networks, computers users can exchange messages and share resources",*is elaborated to: *"In networks, computers users can exchange messages and share resources-such as printing capabilities, software packages, and data storage facilities-that are scattered throughout the system").* (3) Adding sentence connectives (however, therefore, because, so that) to specify the relation between sentences or ideas. In the global macro cohesion versions of the texts (lG and LG), macro propositions were signaled explicitly by various linguistic means (i.e., macro signals): (1) adding topic headers (e.g., Network Classifications, Protocols) and (2) adding macro propositions serving to link each paragraph to the rest of the text and the overall topic (e.g., *"Afterwards, the rules by which network activities are conducted, will be discussed"*) [4].

ALMA supports and assesses students' comprehension through a series of activities such as: text recall, summaries, text-based, bridging inference, elaborative inference, problem solving, case studies, active experimentation and sorting tasks. *Text recall,* helps students remember the basic ideas in the text by translating it into more familiar words. The students are also encouraged to go beyond the basic sentence-focused processing by linking the content of the sentences to other information, either from the text or from the students' background knowledge. The empirical findings have shown that students who are able to recall the text and go beyond the basic sentence-focused processing are more successful at solving problems, more likely to generate inferences, construct more coherent mental models, and develop a deeper understanding of the concepts covered in the text [20]. *Summaries* also encourage students to go beyond the text and like text recall can be perfectly good indicators of well-developed situation models [3]. *Text-based questions,* as they demand only a specific detail from the text, measure text memory. *Bridging-inferences questions* motivate students to make *bridging inferences* which improve comprehension by linking the current sentence to the material previously covered in the text [21]. Such inferences allow the reader to form a more cohesive global representation of the text content (Kintsch, 1998). *Elaborative-inference questions* motivate students to associate the current sentence with their own related background knowledge. The most important is that students are encouraged to engage in logical or analogical reasoning process to relate the content of the sentence with domain-general knowledge or any experiences related to the subject matter, particularly when they do not have sufficient knowledge about the topic of the text. Research has established that both domain knowledge and elaborations based on more general knowledge are associated with improving learning and comprehension [22]. *Elaborations* essentially ensure that the information in the text is linked to information that the reader already knows. These connections to background knowledge result in a more coherent and stable representation of the text content [3, 4]. *Problem-solving questions* motivate students to use the information acquired from the text productively in novel environments. This requires that the text information be integrated with the students' background knowledge and become a part of it, so that it can support comprehension and problem solving in new situations [3]. *Sorting task* has great potential as a simple task and can be used both as a method of assessment and as a mode of instruction. Students are asked to sort a set of key words contained and not contained in the text, in certain groups. They are encouraged to do this task twice, once before reading the text and once more after reading the text. The sorting data are used to determine how strongly reading the text affected students' conceptual structure concerning the information in the text. We are interested in the degree to which the information presented in the text influences their sorting. Sorting task is an alternative method for assessing situation model understanding. *Active experimentation activities* motivate students to undertake an active role and through experimentation to construct their own internal representations for the concept they are studying. *Case studies* motivate students to engage in the solution of an authentic and thus interesting problem. They are asked to analyze it and propose solutions. The problem is described in detail and is followed by a series of questions aiming to guide the students in the problem solving procedure.

Moreover ALMA supports multiple Informative, Tutoring and Reflective Feedback Components, aiming to stimulate learners to reflect on their beliefs, to guide and tutor them towards the achievement of specific learning outcomes and to inform them about their performance [25]. ALMA also actively engages students in the learning process by taking into account readers' learning preferences in order to propose them to start from activities that match their learning preferences and continue with less "learning preferences matched" activities in order to develop new capabilities [26]. To achieve this goal, it suggests that the student performs the "Learning-Style Inventory (LSI ©*1993 David A. Kolb, Experience-Based Learning Systems,Inc.)"*. The Learning – Style Inventory describes the way a student learns and how he/she deals with ideas and day-to-day situations in his/her life. It includes 12 sentences with a choice of endings. Consequently, ALMA is adapted to students' background knowledge and learning style resulting in personalized learning.

ALMA also includes the authoring tool (ALMA_auth). This tool provides the author with the option of developing and uploading the educational material. Finally, ALMA includes a *forum* where students have the possibility to collaborate with each other and also with the instructor.

6. The Assessment of ALMA environment

The Empirical Study demonstrated that ALMA could be a valuable tool for supporting the learning process in introductory computer science courses and helping students to deepen their understanding in the undergraduate curricula of computer science. Students had a positive opinion about ALMA environment because they were activated to use their background knowledge while reading and they believe that ALMA gives the opportunity to achieve better results in learning from texts in computer science than reading a single text target at an average reader. Moreover, students had a positive opinion about the learning sequence proposed by ALMA and they believe that a combination of the traditional teaching method and ALMA environment would be the best for their under and postgraduate studies. The assessment of ALMA demonstrated that the ALMA environment satisfactorily supported the learning process of students in Computer Science and almost all its functions are useful and user-friendly.

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